Time domain Measurements of the Fischer F-65 Current Probe
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The Fischer current probe has been used to measure the HMM current waveform produced by IEC guns when testing interface IC's. Fischer provides the frequency response of this probe from 10 kHz to 1 GHz, calibrated in dB. Please note that 1 dB in is 12.2 % in voltage or current. This report identifies the F-65 current probe response in the time domain, which is intended to improve the accuracy when measuring HMM waveforms.

Accurate pulse response measurement of a current probe requires that high speed current with known characteristics are passed through it. This requires that controlled impedance be maintained in the current path at somewhat faster speeds than are to be measured. A coaxial 50 ohm transmission line with these characteristics would assume rather large dimensions. It would also require that the transmission line be well terminated. An RF Standing Wave Ratio of less than 1.01 would be needed to achieve accuracy within 0.1 dB. Time domain measurements do not require that the current supply line be terminated. The pulse response can be measured only during the time the current passes through the current sensor. We measured the response of the Fischer current probe by locating it around a 100 ohm conical radiator where it is connected to a large ground plane.

The 100 ohm conical radiator extends from the ground plane as shown in figure 1. It provides voltage and current fields which are determined by the source amplitude and its controlled radiation impedance. The cone half angle for the 100 ohm cone is about 21.7 degrees. This is a more reasonable size than the 41.0 degree half angle needed for a 50 ohm conical radiator. The 100 ohm cone feed impedance is used because of our large selection of HV fast pulse 100 ohm coaxial components. We designed and developed them for measurements at the Nevada Test Site. Our primary customer, EG&G split their 50 ohm signals into dual 100 ohm lines for measurements with their high speed 100 ohm impedance oscilloscopes. They recorded signals which were generated during the underground nuclear testing program at the Nevada Test Site some years ago.

The pulse source used for these measurements was our Model 632 with a 50 ps risetime and flat pulse which is produced by discharging a transmission line. The pulse used for this test was about 10 ns long. The 50 ohm output impedance had an abrupt 50 ohm to 100 ohm impedance discontinuity at the 100 ohm coaxial transmission line feeding the conical radiator. The conical radiator is located at the center of our 2 meter diameter aluminum ground plane. The reflections from the 50 to 100 impedance transition and from the end of the conical radiator were outside the scope measurement window. The probe output signal was measured with a 6 GHz scope. The photo in Figure 1 below shows the setup used for our first test of the current probe response. The probe was located close to the ground plane to capture the maximum amount of H plane current. Adjustable length strings hold the copper cone perpendicular to the ground plane. The center conductor of 100 ohm coax connection to the apex of the 100 ohm conical radiator is less than 1 mm diameter.

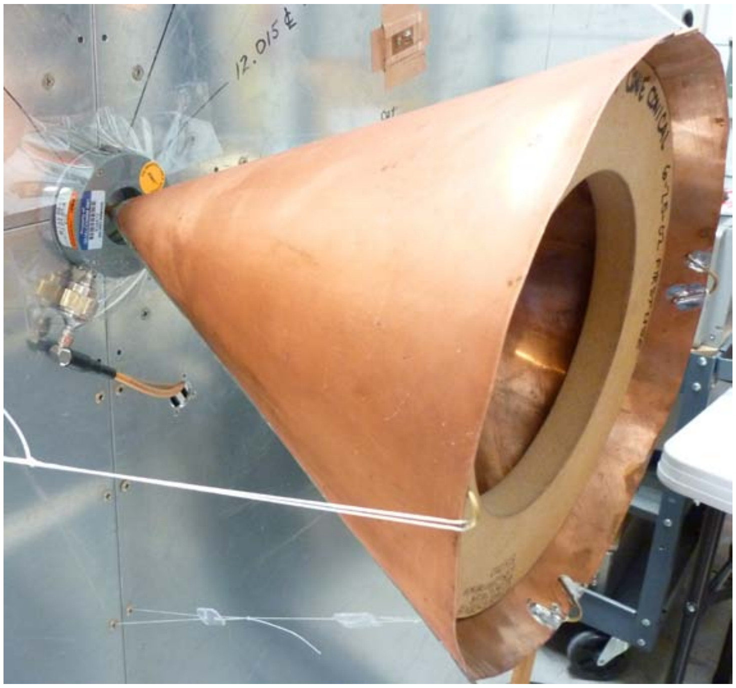

Figure 1. The 12 inch long, 100 ohm, copper conical radiator with Fischer probe

The conical radiator provides high speed uniform amplitude current which flows through the Fischer current probe. The current flows on the surface of the 100 ohm conical surface for one nanosecond until it encounters the end of the conical conductor. At that time current that has not been radiated, flows back toward the current sensor. This allows only about two nanoseconds of constant amplitude current waveform passing through the current sensor.

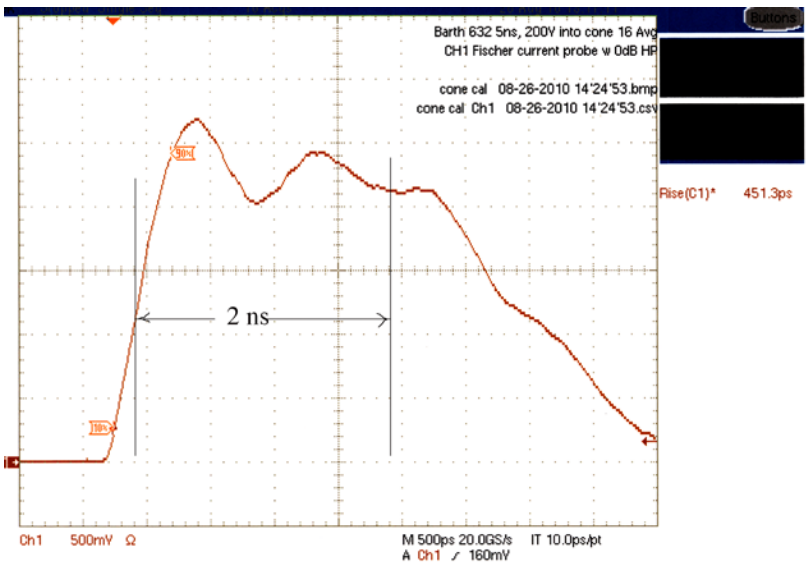

Figure 2. Fischer Current probe pulse response with 12 inch conical radiator

We extended the conical surface with aluminum foil to increase the length of the uniform incident current pulse passing through the current probe. The foul was supported by thick Mylar film held to the contour inside the conical surface. Although the surface of the aluminum foil is wrinkled, high speed currents do not reach that area because they have been radiated during their flow across the smooth copper surface.

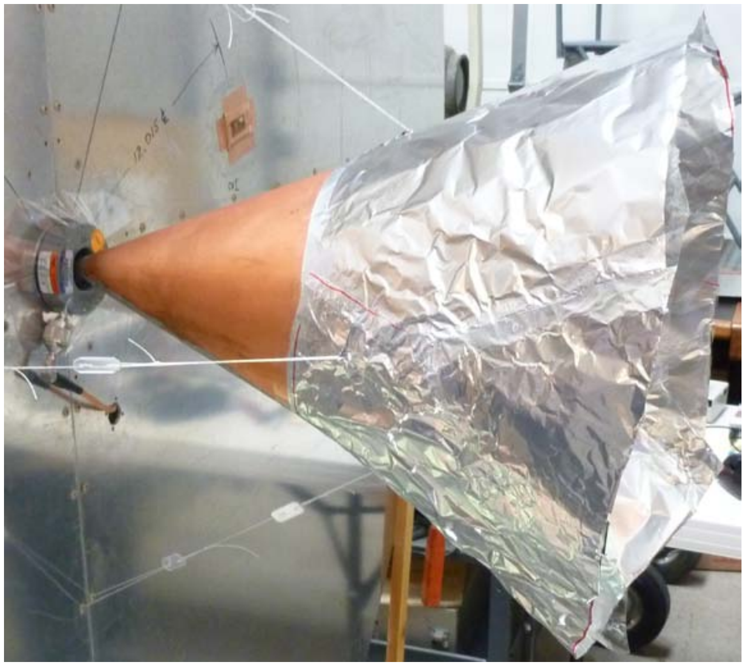

Figure 3. Extended length 100 ohm conical radiator with Fischer probe

The longer pulse response of the Fischer current probe is shown below.

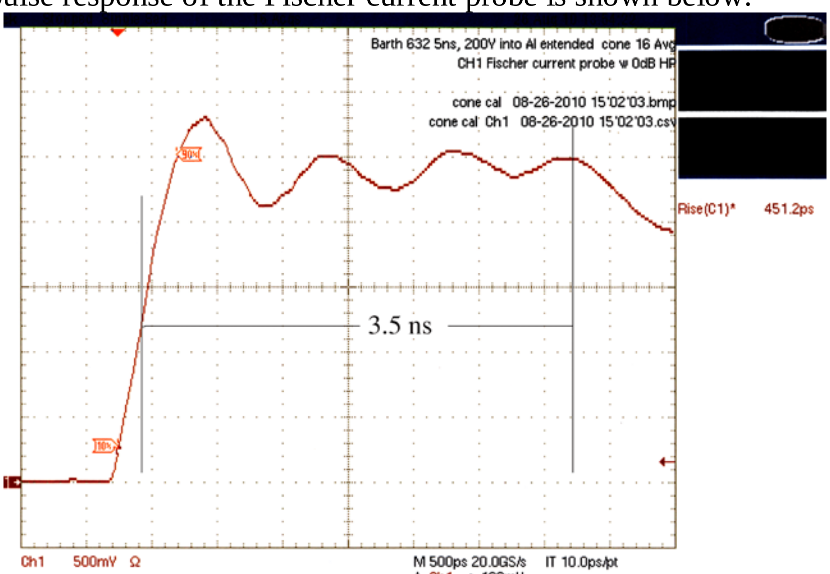

Figure 4. Fischer Current Probe pulse response extended out to 3.5 ns

The overshoot measures about 19 % at the leading edge of the pulse which is typically caused be overcompensation in the probe construction. Although the 6 GHz scope measured the risetime of the probe to be 450 picoseconds, this risetime is enhanced by overcompensation. The overshoot makes it difficult to accurately identify the response of IEC guns in the time domain because it accentuates the early time response. This adds to existing errors from excessive tolerances in the IEC/HMM specification for pulse generation.

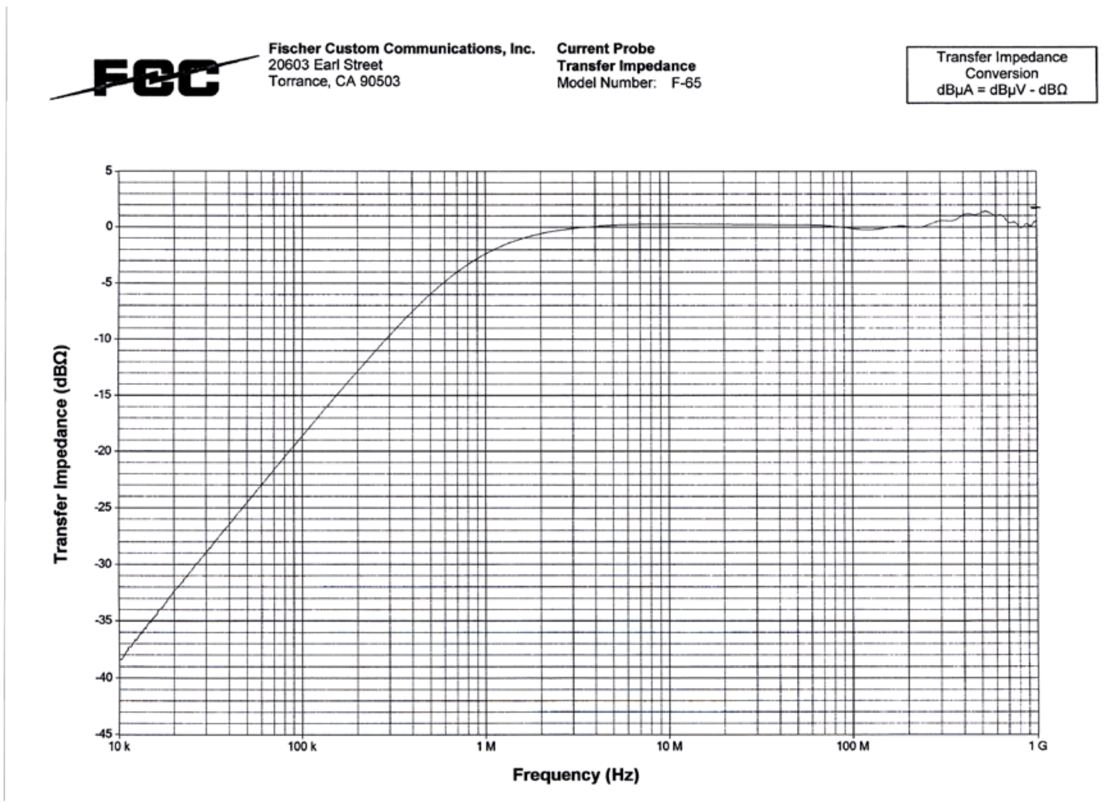

Figure 5. Fischer F-65 Current probe response in the frequency domain

This frequency response shows the current sensitivity increasing from 300 MHz to 800 MHz; peaking to 1.3 dB at 520 MHz. 1.3 dB increase is a voltage/current sensitivity increase of 16% in the time domain. The cycle to cycle ringing calculates to be about 980 MHz, which would cause a fairly narrow peak sensitivity increase in the frequency domain. Their measured frequency domain response indicates that it retains reasonable response 1 GHz. However our measurement of the probe risetime is 451 ps. If the probe's time domain had no overshoot, its 451 ps risetime response would have a frequency response down 3 dB at 780 MHz.

Frequency domain response in dB does not necessarily provide sufficient information details needed for accurate time domain measurements. That is especially true when the response has a non-Gaussian response such as overshoot. Because ESD occurs in the time domain, any frequency domain specifications for instrumentation should also have its response identified in the time domain.